

Divergent drivers of enteric disease burden in six East Asian settings, 1990–2023: a decomposition analysis of the Global Burden of Disease Study 2023

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Abstract

Background

Enteric infections are often regarded as resolved in East Asia, yet the region spans nearly the full socio-demographic spectrum. Whether recent changes in burden reflect changes in age-specific risk or in population age structure is unknown.

Methods

Using Global Burden of Disease (GBD) 2023 estimates, we analysed age-standardised prevalence, incidence, years lived with disability, years of life lost and disability-adjusted life-years (DALYs) for diarrhoeal diseases and typhoid and paratyphoid fevers in China, Japan, the Republic of Korea, the Democratic People's Republic of Korea (DPRK), Mongolia and Taiwan from 1990 to 2023, stratified by age, sex and risk factor. Trends were summarised as estimated annual percentage change (EAPC). We decomposed the change in crude rates, using an exact log identity, into epidemiological (age-standardised rate) and demographic (population age structure) components, and characterised the age distribution of prevalent cases. Analyses were repeated with a 2022 endpoint because 2023 non-fatal estimates for China and Japan showed a discontinuity.

Results

Age-standardised prevalence of diarrhoeal diseases fell in China (EAPC – 5.16%) and Mongolia (– 4.76%) and rose in the DPRK (7.04%) and Taiwan (4.07%). Decomposition identified two mechanisms. In the DPRK the increase was almost entirely epidemiological (age-specific risk + 683.6%, ageing – 3.5%); in Taiwan risk dominated (+ 235.4%), with ageing contributing one fifth (+ 32.2%). Conversely, in the Republic of Korea a 62.0% fall in risk was offset by ageing (+ 88.8%), and in Japan crude DALY rates rose 24.0% although age-standardised rates fell 25.3%. With a 2022 endpoint, findings for the DPRK, Taiwan, the Republic of Korea and Mongolia were unchanged; in Japan the age-standardised fall narrowed to 3.6% but crude rates still rose (+ 34.6%) through ageing (+ 39.7%). The mean age of prevalent cases rose in all six settings, from 25.0 to 53.7 years in Taiwan, where the proportion aged 60 years and older rose from 20.6% to 61.2%. Typhoid and paratyphoid fevers remained rare and declined throughout.

Conclusions

Rising enteric burden in the DPRK and Taiwan reflects genuine increases in age-specific risk, whereas apparent increases in Japan are demographic. Crude and mortality-based indicators alone misread progress in rapidly ageing populations; age-standardised and crude measures should be reported together.

Background

Enteric infections, including diarrhoeal diseases and typhoid/paratyphoid fever, remain major causes of morbidity and mortality worldwide, particularly in low- and middle-income countries [1]. Despite substantial improvements in access to safe water and sanitation, vaccine coverage, and child survival over recent decades, diarrhoeal diseases still account for a considerable burden of disability and health systems [2, 3].

Diarrhoeal diseases and typhoid/paratyphoid fevers show substantial heterogeneity across settings, reflecting differences in water, sanitation, and food safety [4]. This heterogeneity is particularly evident in East Asia, which encompasses wide variation in socioeconomic development, health-system capacity, and infrastructure. The region spans high-income settings such as Japan and the Republic of Korea (ROK), where improved sanitation coverage is essentially universal [5], alongside settings such as Mongolia, where improved sanitation coverage is lower than in high-income setting [5], and the Democratic People's Republic of Korea (DPRK), where safely managed drinking-water services remain limited when water quality and availability are considered [6]. Understanding how patterns of enteric infection have evolved across this spectrum, and how they may change in the coming decades, is crucial for health security, monitoring progress towards the Sustainable Development Goals (SDGs), and planning for prevention and care [7].

The Global Burden of Disease (GBD) study provides internally consistent estimates of cause-specific incidence, prevalence, years lived with disability (YLDs), years of life lost (YLLs), and disability-adjusted life-years (DALYs) for nearly all countries on an annual basis since 1990. Previous GBD-based analyses of these causes have focused mainly on global typhoid and paratyphoid trends and on the geography of outbreaks [8, 9]. However, to our knowledge, no study has specifically focused on diarrhoeal diseases and typhoid/paratyphoid in East Asia, integrating time trends and spatial patterns across countries with such contrasting levels of development. Since this analysis was completed, the GBD 2023 enteric infections collaborators have published global estimates for these causes across 204 countries and territories [10]. That global synthesis reports region- and country-level totals, but does not compare settings within East Asia, does not consider the DPRK and Taiwan alongside their high-income neighbours, and does not examine the age- and sex-specific patterns through which these divergent trajectories arise; these are the gaps the present study addresses.

We aimed to (1) describe long-term trends in the age-standardised prevalence and DALYs of diarrhoeal diseases and typhoid/paratyphoid fevers in six East Asian countries and territories (China, Japan, ROK, DPRK, Mongolia, and Taiwan) from 1990 to 2023; (2) compare age-standardised levels in 1990 and 2023 and characterise sex-specific trends over time; (3) describe age-specific patterns in 1990 and 2023; and (4) examine complementary burden metrics, including incidence, YLDs, YLLs, and DALYs attributable to major risk factors. We extracted publicly available estimates from the Global Burden of Disease (GBD) 2023 Study, which is coordinated by the Institute for Health Metrics and Evaluation (IHME). This study is

reported in accordance with the Guidelines for Accurate and Transparent Health Estimates Reporting (GATHER) statement [11].

Methods

Study overview

This study presents GBD 2023 estimates to describe the burden of two enteric disease groups—diarrhoeal diseases and typhoid and paratyphoid fevers—across six countries and territories in East Asia (China, Japan, the Republic of Korea, the Democratic People’s Republic of Korea, Mongolia, and Taiwan).

GBD 2023 estimates for diarrhoeal diseases and typhoid and paratyphoid fevers were originally produced by the GBD 2023 Causes of Death Collaborators [12] and GBD 2023 Disease and Injury and Risk Factor Collaborators [13], and shared publicly in the GBD Results Tool (<https://vizhub.healthdata.org/gbd-results/>); this study assesses and presents details of these findings specific to six East Asian settings. We extracted the published GBD 2023 outputs and did not re-estimate any GBD models; all epidemiological measures analysed were taken directly from the official GBD 2023 estimates. Case definitions used in GBD 2023 for both cause groups are summarised in **Additional file 1: Table S2**.

GBD 2023 estimates for non-fatal health outcomes were generated using a Bayesian meta-regression tool, DisMod-MR 2.1, which integrates heterogeneous data sources and ensures internal consistency across epidemiological parameters. In this study, we analysed prevalence and DALYs to quantify disease burden. DALYs represent the total health loss due to both non-fatal and fatal outcomes, calculated as the sum of YLDs and YLLs. Age-standardised rates (ASRs) were calculated using the GBD standard population to allow comparisons across locations and over time. Estimated annual percentage change (EAPC), which summarises the long-term trend in age-standardised rates, was calculated by us from the extracted GBD 2023 age-standardised rates; EAPC is not itself reported by GBD.

Statistical analysis

Temporal trends were assessed using the estimated annual percentage change (EAPC) and its 95% confidence interval (CI). For each combination of cause, location, sex, and measure, a log-linear regression of the age-standardised rate on calendar year was fitted over 1990–2023 (34 annual observations), $\ln(\text{ASR}) = \alpha + \beta \times \text{year} + \epsilon$. EAPC was derived as $100 \times (\exp(\beta) - 1)$ and its 95% CI as $100 \times (\exp(\beta \pm 1.96 \times \text{SE}(\beta)) - 1)$. A trend was considered to be significantly increasing if both the EAPC point estimate and the lower boundary of its 95% CI were greater than zero, and significantly decreasing if both the estimate and the upper boundary were less than zero. Data management, statistical analyses and visualisations were performed in R versions 4.2, 4.4.2 and 4.5.3 (R Foundation for Statistical Computing, Vienna, Austria).

Decomposition of burden change into demographic and epidemiological components

To separate change driven by shifts in population age structure from change in underlying age-specific risk, we decomposed the change in the crude rate between 1990 and 2023. Because the age-standardised rate holds the age distribution fixed at the GBD world standard population, the crude rate can be written exactly as the age-standardised rate multiplied by a term reflecting the difference between a country's own age structure and that standard, so that $\log(\text{crude rate}) = \log(\text{ASR}) + \log(\text{crude rate} / \text{ASR})$. Differencing this identity between 1990 and 2023 yields an exact additive decomposition of the total change into an epidemiological component, the change in the age-standardised rate, and a demographic component, the change in the age-structure term. Crude rates were obtained by dividing all-age case counts by the corresponding GBD 2023 population estimates. Contributions are reported on the natural log scale, on which they are additive, and are additionally expressed as percentage changes. Expressing the demographic component as a share of the total change is uninformative when the total change approaches zero or when the two components act in opposite directions; in those settings we report the absolute log contributions instead.

We additionally characterised the age distribution of disease directly, using age-specific prevalent case counts for thirteen age groups. For each country and year we calculated the proportion of all prevalent cases occurring in children younger than 5 years and in adults aged 60 years and older, together with the mean age of prevalent cases, computed using age-group midpoints. These quantities are derived from case counts alone and are therefore independent of the choice of standard population.

Data sources used to produce GBD 2023 estimates are listed in the GBD 2023 Sources Tool (<https://ghdx.healthdata.org/gbd-2023/sources>). Metadata and citations for the input data specific to this study can be obtained by selecting “causes of death or injury” for components, “Diarrheal diseases” and “typhoid and paratyphoid fevers” for causes, and “China”, “Japan”, “Republic of Korea”, “Democratic People’s Republic of Korea”, “Mongolia”, and “Taiwan” for locations See GBD 2023 Causes of Death Collaborators [12] GBD 2023 Disease and Injury and Risk Factor Collaborators [13] for details on how input data were processed.

Calculating uncertainty

Uncertainty intervals (UIs) for GBD estimates represent the 2.5–97.5 percentiles across 250 draws from the GBD 2023 posterior distribution. Confidence intervals for the EAPC reflect uncertainty in the fitted log-linear trend only and do not propagate the GBD uncertainty intervals; decomposition components and age-composition measures were calculated from point estimates and are presented without uncertainty intervals.

GBD researching and reporting practices

GBD 2023 complies with the GATHER guidelines [11]; the GATHER checklist for this study is provided in Additional file 2: Table S1. The original GBD 2023 analyses were completed using Python versions 3.8–17

and 3·10·4, Stata version 15·1, and R versions 3·5 and 4·2. The statistical code used in GBD 2023 is publicly available online (<http://ghdx.healthdata.org/gbd-2023/code>).

Sensitivity analysis

Inspection of the annual series showed a discontinuity in the final year of the GBD 2023 non-fatal estimates of diarrhoeal diseases in two settings. Between 2022 and 2023, age-standardised prevalence rose by 113.6% in China and fell by 29.3% in Japan, with changes of similar size in incidence (+ 103.9% and – 31.9%) and YLDs (+ 113.4% and – 29.4%). Over 1991–2022 the median absolute year-on-year change in age-standardised prevalence had been 4.1% in China and 1.0% in Japan, and the largest single-year change 15.9% and 6.4%. Age-standardised YLL rates changed by – 7.7% and + 4.9%, within their historical range, and in the other four settings the change between 2022 and 2023 in every non-fatal measure was smaller than the setting's own median annual change (Additional file 3: Table S29). A single-year change of this size, confined to non-fatal measures in two settings, is more plausibly a feature of the final-year estimates than an epidemiological event, although its cause cannot be established from the published estimates. We therefore retained 1990–2023 as the primary analysis period, consistent with GBD 2023 reporting, and repeated every endpoint-dependent analysis, namely the EAPC, the decomposition and the age composition of prevalent cases, with 2022 as the endpoint (Additional file 3: Tables S30–S32).

Results

Age-standardised prevalence of diarrhoeal diseases in 2023 showed marked heterogeneity across the six East Asian settings, ranging from 1,098.90 per 100,000 in the DPRK to 84.66 per 100,000 in the ROK. Between 1990 and 2023, prevalence declined markedly in China (489.76 to 241.21; EAPC – 5.16%) and Mongolia (227.46 to 43.58; EAPC – 4.76%), whereas pronounced increases were observed in the DPRK (140.25 to 1,098.90; EAPC 7.04%) and Taiwan (252.96 to 848.34; EAPC 4.07%), indicating divergent long-term trajectories across the region. Japan and the ROK experienced minimal changes over time, with near-zero EAPCs (0.65% and 0.09%, respectively), and consistently remained among the lower-prevalence settings throughout the study period (Table 1; Fig. 1). Patterns for DALYs were broadly consistent with those observed for prevalence but showed sharper contrasts in magnitude. Substantial declines in age-standardised DALY rates were observed in both China (774.54 to 37.02 per 100,000; EAPC – 11.40%) and Mongolia (1,218.93 to 24.48 per 100,000; EAPC – 12.15%), with Mongolia exhibiting the steepest relative decline over the study period. In contrast, DALY rates in the DPRK were higher in 2023 than in 1990 (128.89 to 152.19 per 100,000; EAPC 0.53%). Japan and the ROK maintained relatively low DALY rates throughout the study period, with small to moderate changes over time (Table 1; Fig. 1). Consistent patterns were observed for age-standardised incidence, YLDs, and YLLs, with increasing incidence and YLDs in the DPRK and Taiwan, and marked declines in YLLs in China and Mongolia (Additional file 1: Table S4 and Figures S1–S3).

Table 1
Trends in age-standardised prevalence and DALYs of diarrhoeal diseases, 1990–2023

Prevalence	1990 ASR	2023 ASR	EAPC (%)
China	489.76 (421.51–578.50)	241.21 (192.82–303.60)	–5.16 (– 5.83 to – 4.48)
Japan	429.24 (354.70–535.52)	336.46 (277.52–411.60)	0.65 (0.24 to 1.07)
ROK	93.11 (77.24–114.38)	84.66 (70.90–103.02)	0.09 (– 0.12 to 0.29)
DPRK	140.25 (119.15–164.88)	1,098.90 (916.23–1,338.60)	7.04 (6.72 to 7.36)
Mongolia	227.46 (190.40–275.39)	43.58 (35.30–54.56)	–4.76 (– 5.48 to – 4.04)
Taiwan	252.96 (222.61–287.30)	848.34 (734.55–987.22)	4.07 (3.65 to 4.49)
DALYs			
China	774.54 (640.16–942.69)	37.02 (27.53–48.93)	–11.40 (– 12.05 to – 10.73)
Japan	69.99 (52.99–90.70)	52.26 (39.83–67.87)	0.25 (– 0.16 to 0.66)
ROK	90.82 (62.12–112.94)	34.54 (25.56–51.05)	–2.10 (– 2.52 to – 1.67)
DPRK	128.89 (73.54–212.44)	152.19 (107.71–206.01)	0.53 (0.25 to 0.82)
Mongolia	1,218.93 (698.77–1,910.01)	24.48 (16.20–35.91)	–12.15 (– 12.57 to – 11.72)
Taiwan	86.31 (75.37–97.56)	102.57 (73.56–136.78)	1.08 (0.33 to 1.83)
Data in parentheses are 95% uncertainty intervals, and rates are expressed per 100 000 population. Abbreviations: ROK, Republic of Korea; DPRK, Democratic People's Republic of Korea; ASR, Age standardized rate; DALYs: Disability-Adjusted Life Years; EAPC, Estimated Annual Percentage Change.			

Sex-specific analyses showed broadly similar temporal patterns in age-standardised prevalence of diarrhoeal diseases among men and women across the six East Asian settings (Fig. 3; **Additional file 1: Figures S7–S10 and Tables S6–S7**). In both sexes, prevalence declined between 1990 and 2023 in China and Mongolia, whereas increasing trends were observed in the DPRK and Taiwan, with minimal changes in Japan and the ROK. Comparable sex-specific patterns were observed for incidence, with marked increases in the DPRK and Taiwan and declines in China and Mongolia. Age-standardised DALY rates decreased substantially among both men and women in China and Mongolia, largely driven by pronounced reductions in YLLs. In contrast, sex differences were observed in the DPRK and Taiwan,

where DALY rates declined or remained stable among men but increased among women, reflecting larger increases in YLDs among women in these settings.

Age-specific analyses of prevalence revealed pronounced age gradients in both 1990 and 2023 (Fig. 4; **Additional file 1: Tables S10–S15**). Across settings, prevalence of diarrhoeal diseases was highest among young children, particularly those under 5 years of age, in 1990. By 2023, age-specific patterns diverged substantially across countries. In China, prevalence and DALY rates declined markedly across all age groups between 1990 and 2023, with the largest absolute reductions observed among infants and young children (**Additional file 1: Table S10**). Although prevalence among adolescents and adults showed more modest changes, absolute levels declined even among older age groups, including those aged 70 years and older. In contrast, Taiwan exhibited marked increases in age-specific prevalence and DALY rates across most age groups by 2023, with particularly steep increases among older adults (**Additional file 1: Table S15**). As a result, the age distribution of burden in Taiwan shifted towards a marked U-shaped pattern in 2023, characterised by high prevalence among both young children and older age groups. Age-stratified analyses of DALYs attributable to major risk factors indicated that child growth failure and other nutrition-related risks contributed meaningfully to the burden primarily among children younger than 5 years, whereas among older children, adults, and older age groups, the vast majority of attributable DALYs were explained by environmental risk factors, particularly unsafe water and sanitation (**Additional file 1: Tables S22–S27**). Across countries, the composition of risk factors beyond early childhood remained largely stable over time, while the magnitude of attributable DALYs varied substantially by setting in 2023.

Decomposing the change in crude prevalence of diarrhoeal diseases between 1990 and 2023 showed that the divergent trajectories described above arise from two distinct mechanisms (Fig. 5; **Additional file 3: Table S28**). In the DPRK the increase was almost entirely epidemiological: age-specific risk rose by 683.6% while the contribution of population ageing was negligible and slightly negative (– 3.5%). In Taiwan, ageing contributed materially but did not dominate, with age-specific risk rising by 235.4% against an ageing contribution of 32.2%, so that approximately one fifth of the increase in crude prevalence was demographic. The rising non-fatal burden in these two settings therefore reflects genuine increases in age-specific risk rather than changing population composition alone. Declines in China and Mongolia were likewise predominantly epidemiological, with age-standardised prevalence falling by 50.8% and 80.8% against ageing contributions of – 2.4% and – 26.3%.

The opposite configuration was observed for fatal burden in the high-income settings. In Japan, age-standardised DALY rates fell by 25.3% between 1990 and 2023, yet crude DALY rates rose by 24.0%, because population ageing contributed 66.1%; the apparent increase in burden was therefore wholly demographic. A similar but less extreme pattern was seen in the Republic of Korea, where a 62.0% reduction in age-specific risk was substantially offset by an ageing contribution of 88.8%, leaving a 28.2% decline in the crude rate. In China and Mongolia, by contrast, reductions in crude DALY rates of 95.5% and 98.6% were driven almost entirely by falls in age-specific risk, of 95.2% and 98.0% respectively.

Direct examination of the age distribution of prevalent cases confirmed a pronounced regional shift from children towards older adults (Fig. 6). The proportion of prevalent diarrhoeal cases occurring in children younger than 5 years fell in every setting, most steeply in Mongolia (66.8% to 22.7%), the DPRK (48.6% to 6.1%), China (44.9% to 4.2%) and Taiwan (41.8% to 8.5%). Over the same period the proportion of cases in adults aged 60 years and older rose from 20.6% to 61.2% in Taiwan, from 16.8% to 49.0% in Japan and from 8.5% to 43.4% in the Republic of Korea. The mean age of prevalent cases increased in all six settings, from 25.0 to 53.7 years in Taiwan, from 29.9 to 47.8 years in Japan, from 23.3 to 46.3 years in the Republic of Korea, from 17.6 to 35.7 years in the DPRK, from 14.4 to 34.5 years in China and from 6.3 to 18.7 years in Mongolia.

Repeating the analyses with 2022 as the endpoint left the principal findings unchanged (Additional file 3: Tables S30–S32). EAPCs were stable in every setting because the log-linear trend draws on all annual observations: for age-standardised prevalence the EAPC was – 5.65% rather than – 5.16% in China and 0.93% rather than 0.65% in Japan, and differed by less than 0.2 percentage points elsewhere; for age-standardised DALY rates in Japan it was 0.49% (95% CI 0.16 to 0.82) rather than 0.25% (– 0.16 to 0.66). The decomposition of prevalence was essentially unchanged for the DPRK (age-specific risk + 664.0%, ageing – 3.6%), Taiwan (+ 230.2%, + 29.2%) and Mongolia (– 80.8%, – 26.1%), as was the decomposition of DALYs for the Republic of Korea (– 62.6%, + 80.6%). For China the direction was unchanged but the fall in age-standardised prevalence was larger (76.9% rather than 50.8%). Japan was the exception. With a 2022 endpoint, age-standardised prevalence rose by 10.8% rather than falling by 21.6%, and the fall in age-standardised DALY rates narrowed from 25.3% to 3.6%; crude DALY rates nonetheless rose by 34.6%, with an ageing contribution of 39.7%, so that the increase in crude burden remained demographic in origin. The shift in the age distribution of prevalent cases from children towards older adults was present in all six settings under both endpoints, although the 2023 values were sensitive to the endpoint for China (proportion aged 60 years and older 12.6% in 2023 and 20.9% in 2022; mean age 34.5 and 37.9 years) and Japan (49.0% and 42.7%; 47.8 and 44.2 years).

For typhoid and paratyphoid fevers, age-standardised prevalence and DALY rates remained low across all settings in both 1990 and 2023 (**Additional file 1: Table S3**; Fig. 2). Among the six locations, China consistently exhibited the highest burden in 2023, with an age-standardised prevalence of 0.58 per 100,000 and a DALY rate of 4.91 per 100,000. Over time, declines were observed in China and the DPRK for both prevalence (EAPCs – 2.21% and – 5.37%, respectively) and DALYs (EAPCs – 2.88% and – 4.97%, respectively). In contrast, the Republic of Korea and Mongolia maintained near-zero levels of prevalence and DALYs throughout the study period, with consistently low rates over the study period. Similarly, age-standardised incidence, YLDs, and YLLs remained low and generally declined across all settings over the study period (**Additional file 1: Table S5 and Figures S4–S6**).

Sex-specific analyses of typhoid and paratyphoid fevers showed broadly similar patterns among men and women across all six East Asian settings (Fig. 3; **Additional file 1: Figures S11–S14 and Tables S8–S9**). In both sexes, age-standardised prevalence, incidence, DALYs, YLDs, and YLLs remained at very low levels throughout the study period. Declines over time were observed in China, the DPRK, and Taiwan for

most indicators, whereas near-zero levels were maintained in the Republic of Korea and Mongolia. Overall, no substantial sex differences were observed in temporal trends or burden patterns for typhoid and paratyphoid fevers. Age-specific analyses of typhoid and paratyphoid fevers showed consistently low prevalence across all age groups in both 1990 and 2023 (Fig. 4; **Additional file 1: Tables S16–S21**). In China, prevalence was modestly higher among young children, particularly those under 5 years of age, but declined progressively with increasing age (**Additional file 1: Table S16**). Between 1990 and 2023, age-specific prevalence generally decreased across most age groups, while DALY rates declined consistently across all ages.

Discussion

In this study, we provide a comprehensive assessment of long-term trends in the burden of diarrhoeal diseases and typhoid and paratyphoid fevers across six East Asian settings from 1990 to 2023. Our findings reveal marked heterogeneity in diarrhoeal disease burden, characterized by divergent trajectories that reflect varying stages of epidemiological transition. While China and Mongolia achieved substantial and sustained declines in prevalence and DALYs—driven largely by a reduction in early childhood mortality (YLLs)—these gains were contrasted by pronounced increases in the DPRK and Taiwan. Notably, the burden in Taiwan shifted towards a U-shaped age distribution, signaling an emerging challenge in the older population. These disparities were consistent across sexes and multiple burden indicators, suggesting that localized factors, including socioeconomic development and aspects of infrastructure maintenance, play a critical role. In contrast, typhoid and paratyphoid fevers remained consistently rare and stable across all settings, indicating successful management of these specific enteric pathogens throughout the region [14].

The pronounced heterogeneity in diarrhoeal disease trends across East Asia likely reflects disparities in access to safely managed water and sanitation infrastructure, the resilience of primary health care systems, and the pace of broader socioeconomic transition. In China, Mongolia, and the ROK, sustained declines in DALYs and YLLs are consistent with long-term investments in nationwide water-sanitation projects and strengthened primary health care, alongside rising socioeconomic development as reflected by SDI indicators [15–17]. In contrast, the persistence or increase of non-fatal burden in the DPRK and Taiwan indicates that improvements in clinical outcomes have not been uniformly accompanied by reductions in environmental exposure risks. Although Taiwan and the DPRK exhibit superficially similar increases in non-fatal burden, the underlying pathways appear to differ. In the DPRK, the burden is largely driven by structural vulnerability, with chronic deficiencies and the systemic lack of basic water and sanitation infrastructure resulting in sustained exposure to enteric pathogens across age groups [16]. In Taiwan, by contrast, our decomposition shows that population ageing contributed to the rise but accounted for only about one fifth of the increase in crude prevalence, with the larger part attributable to a genuine increase in age-specific risk. This may reflect increased detection of recurrent or non-fatal diarrhoeal conditions within a highly sensitive and well-resourced health system, together with sustained environmental exposure, rather than a deterioration in basic water and sanitation coverage. The persistence of non-fatal burden despite high economic development suggests that gains

in survival have not been fully matched by sustained reductions in environmental exposure risks, which may also be influenced by vulnerabilities related to extreme precipitation and temperature variability [18].

Our findings suggest a life-course pattern in which the relative contribution of nutritional susceptibility and environmental exposure to diarrhoeal disease burden varies by age. While child growth failure remains a key risk factor among children under 5, reflecting heightened biological vulnerability, environmental risk factors contribute substantially to disease burden across age groups beyond early childhood, with their impact on DALYs becoming more pronounced in older age groups. This pattern indicates that reductions in mortality during early childhood do not necessarily translate into sustained reductions in morbidity later in life, underscoring the importance of maintaining environmental safety and infrastructure across the life course. Sex-specific differences were comparatively modest but showed a tendency towards higher YLDs among women in certain settings. These patterns should be interpreted cautiously and may reflect gendered differences in health-care utilisation, domestic exposure roles, or longer life expectancy resulting in greater accumulation of non-fatal burden, rather than biological susceptibility alone [19].

The contrasting success in controlling typhoid and paratyphoid fevers underscores the efficacy of targeted public health interventions. Unlike the broader category of diarrhoeal diseases, which involves diverse pathogens and transmission routes, typhoid is more amenable to focused strategies such as vaccination, food hygiene regulation, and specific antibiotic treatment [20–23]. Our findings suggest that while specific enteric pathogens can be brought close to elimination through targeted intervention, the broader syndrome of diarrhoeal disease remains entrenched due to complex environmental and structural determinants that require comprehensive rather than solely clinical solutions.

Taken together, these findings suggest that progress assessed solely through mortality indicators may underestimate persistent morbidity related to diarrhoeal diseases in East Asia. The observed decoupling between declines in YLLs and stagnation or increases in YLDs indicates that non-fatal outcomes warrant greater attention in regional burden monitoring frameworks. In settings undergoing epidemiological transition, incorporating non-fatal burden into routine surveillance may provide a more comprehensive assessment of population health and the sustainability of public health gains.

The decomposition also shows why crude and mortality-based indicators can move in the opposite direction to underlying risk. In Japan and the Republic of Korea, age-specific diarrhoeal DALY rates fell substantially between 1990 and 2023, yet population ageing offset or reversed that gain in the crude rate, producing an apparent increase in burden in Japan even though age-specific risk did not rise (a reduction of 25.3% with the 2023 endpoint and of 3.6% with the 2022 endpoint). Surveillance frameworks that monitor crude or all-age counts alone will therefore misread genuine epidemiological progress in rapidly ageing populations, just as mortality-only frameworks understate persistent morbidity. Reporting age-standardised and crude measures together, with the difference between them made explicit, gives a more faithful account of where progress is and is not occurring.

Our regional estimates are drawn from the same GBD 2023 round as the global enteric infections synthesis [10], and the two are therefore consistent by construction; the contribution here lies in the within-region comparison rather than in re-estimating global totals. This study has several limitations inherent to the Global Burden of Disease framework. Estimates rely on the availability and quality of primary data; in settings with limited surveillance capacity, notably the DPRK, greater reliance on modelling and predictive covariates may introduce additional uncertainty in absolute burden levels. Although GBD applies harmonised methods, residual biases related to evolving diagnostic practices—such as the increasing use of sensitive molecular tests in high-income settings—may influence non-fatal burden estimates over time. In addition, national-level analyses cannot fully capture subnational heterogeneity, intersectional inequalities, or pathogen-specific mechanisms underlying the broad syndrome of diarrhoeal diseases. Furthermore, DALYs in the GBD framework primarily capture the acute effects of diarrhoeal diseases and do not account for longer-term consequences such as impaired growth or cognitive development, which may lead to an underestimation of the true lifetime burden. As a secondary analysis, this study also inherits the assumptions and limitations of the underlying GBD 2023 models, including uncertainty related to cause attribution and risk factor estimation. Finally, the GBD 2023 non-fatal estimates for China and Japan showed a discontinuity in 2023 that we could not explain from the published estimates and that is unlikely to reflect a true epidemiological change. Endpoint comparisons for these two settings, and in particular the magnitude of the change in age-standardised rates in Japan, should therefore be interpreted with caution; our sensitivity analysis indicates that the conclusions for the DPRK, Taiwan, the Republic of Korea and Mongolia, and the demographic origin of the rise in crude DALY rates in Japan, do not depend on the choice of endpoint. Nevertheless, the consistent patterns observed across multiple indicators and age groups support the robustness of the main conclusions regarding long-term trends and regional heterogeneity.

Our findings should be interpreted within the broader framework of infectious disease control and structural determinants of health. Despite East Asia's overall economic transition, our results reveal that diarrhoeal diseases continue to function as a marker of structural inequity in the region, manifesting in two distinct patterns. In the DPRK, the rising burden in working-age and older women plausibly reflects classical poverty-related vulnerability—chronic deficits in safely managed water, sanitation, and hygiene (WaSH) infrastructure that disproportionately affect populations with limited access to basic services and that are amplified by recurrent flooding, sanctions-related supply constraints, and limited diagnostic capacity [24]. In Taiwan, by contrast, the persistent non-fatal burden in older adults illustrates a less recognised form of structural inequity, in which population aging and aging environmental infrastructure converge to sustain enteric pathogen exposure even within a high-income setting. Both patterns underscore that progress towards Sustainable Development Goal (SDG) 3.3 (ending preventable communicable disease deaths) and SDG 6.1–6.2 (universal access to safe drinking water and sanitation) cannot be assessed by mortality indicators alone, and that pockets of poverty-related vulnerability persist within and between East Asian settings despite the region's overall epidemiological transition. Sustained reductions will therefore require integrated investments that simultaneously

address WaSH infrastructure, primary care access for the elderly, and surveillance for vulnerable subpopulations [25].

Conclusions

In conclusion, our study reveals divergent trajectories in the burden of diarrhoeal diseases and enteric fevers across East Asia from 1990 to 2023, and shows that superficially similar trends have opposite causes. Decomposition indicates that the rising burden in the DPRK and Taiwan is driven principally by genuine increases in age-specific risk rather than by population ageing, whereas the apparent increase in crude DALY rates in Japan, and the attenuated improvement in the Republic of Korea, are demographic in origin: underlying age-specific risk fell substantially in the Republic of Korea and, under either endpoint, did not rise in Japan. In China and Mongolia the large reductions achieved were overwhelmingly epidemiological, consistent with sustained investment in primary health care and water and sanitation infrastructure. Across the region the burden has shifted decisively from young children towards older adults. These findings argue for surveillance that reports age-standardised and crude measures together, so that demographic and epidemiological change can be told apart, and for integrated public health strategies that extend beyond early childhood and mortality-focused interventions to address environmental exposure and the health of ageing populations.

Abbreviations

ASR

Age-standardised rate

CI

Confidence interval

DALYs

Disability-adjusted life-years

DPRK

Democratic People's Republic of Korea

EAPC

Estimated annual percentage change

GATHER

Guidelines for Accurate and Transparent Health Estimates Reporting

GBD

Global Burden of Disease

IHME

Institute for Health Metrics and Evaluation

ROK

Republic of Korea

SDG

Sustainable Development Goal

SDI
Socio-demographic Index
UI
Uncertainty interval
WaSH
Water, sanitation and hygiene
YLDs
Years lived with disability
YLLs
Years of life lost

Declarations

Ethics approval and consent to participate

Not applicable. This study used aggregated, de-identified estimates from the Global Burden of Disease Study 2023, which are publicly available; no individual-level data were used and no human participants were directly involved.

Consent for publication

Not applicable. This study used aggregated, de-identified, publicly available estimates and contains no individual-level data or identifying information.

Availability of data and materials

This study follows the Guidelines for Accurate and Transparent Health Estimates Reporting (GATHER). To download citations and metadata for the input data sources used in the GBD 2023 analyses presented in this study, please visit the GBD 2023 Sources Tool (<https://ghdx.healthdata.org/gbd-2023/sources>).

Competing interests

The authors declare no competing interests.

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The funders of this study had no role in study design, data collection, data analysis, data interpretation, or writing of the report. The lead and senior authors had full access to all data used in the study and had final responsibility for the decision to submit the manuscript for publication.

Authors' contributions

MK conceived and designed the study, analyzed and interpreted the data, and drafted the manuscript. JK and SJ conceived and designed the study, supervised the analysis, interpreted the data, and critically revised the manuscript. JS, ESK, SHJ, TK, YK, SK, JL, JC, SC, HK, and JHP contributed to data interpretation and reviewed the manuscript. All authors reviewed and approved the final manuscript.

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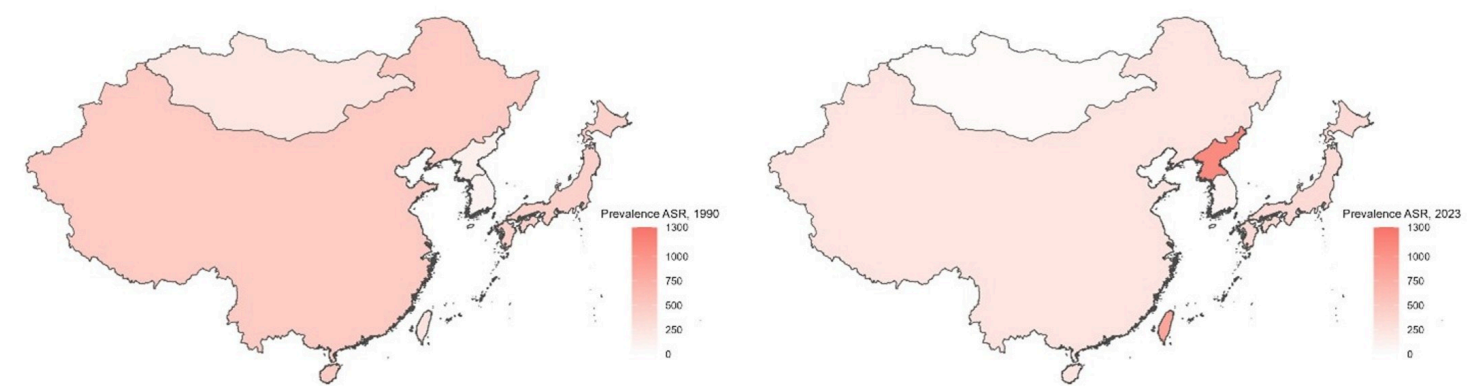
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Figures

A



B

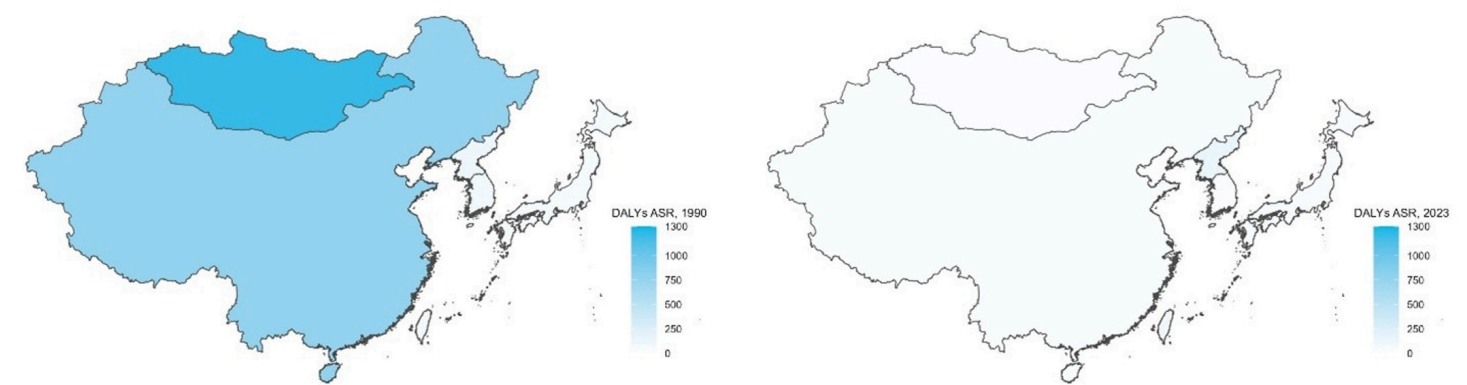


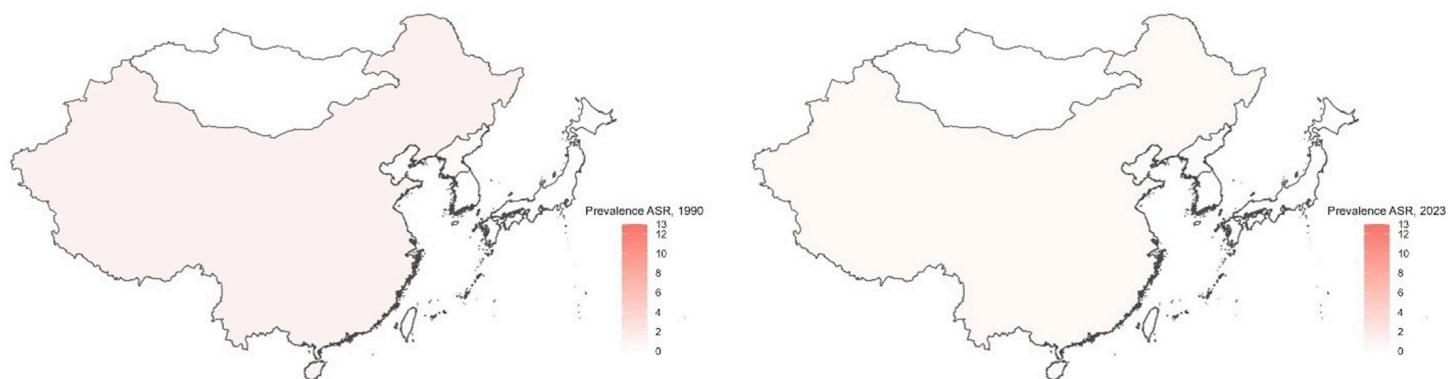
Figure 1

Age-standardised prevalence and DALYs of diarrhoeal diseases in 1990 and 2023

(A) Prevalence, (B) DALYs. Rates are expressed per 100 000 population. Panel A shows prevalence and panel B shows DALYs; the left panel represents 1990 and the right panel represents 2023.

Abbreviations: ASR, age-standardised rate; DALYs, disability-adjusted life-years.

A



B

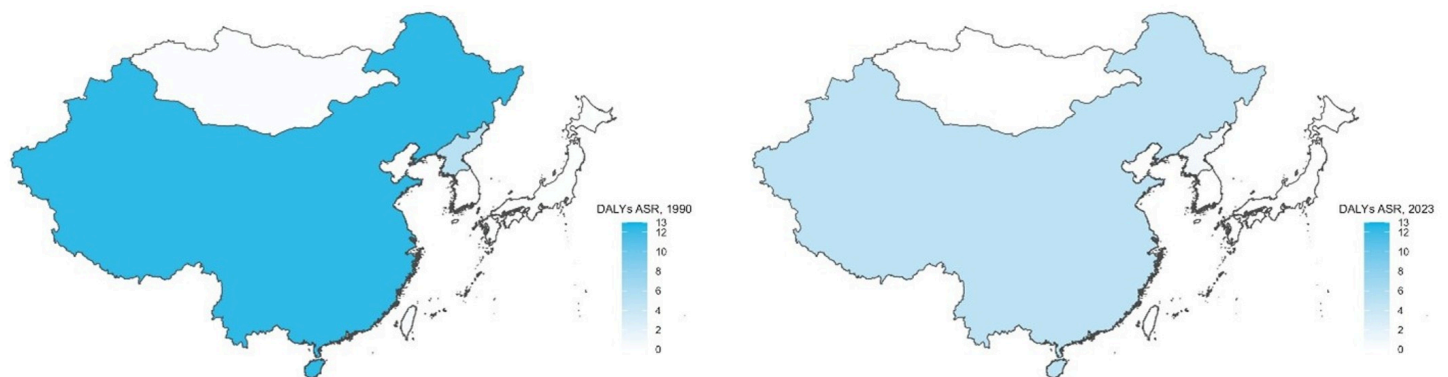


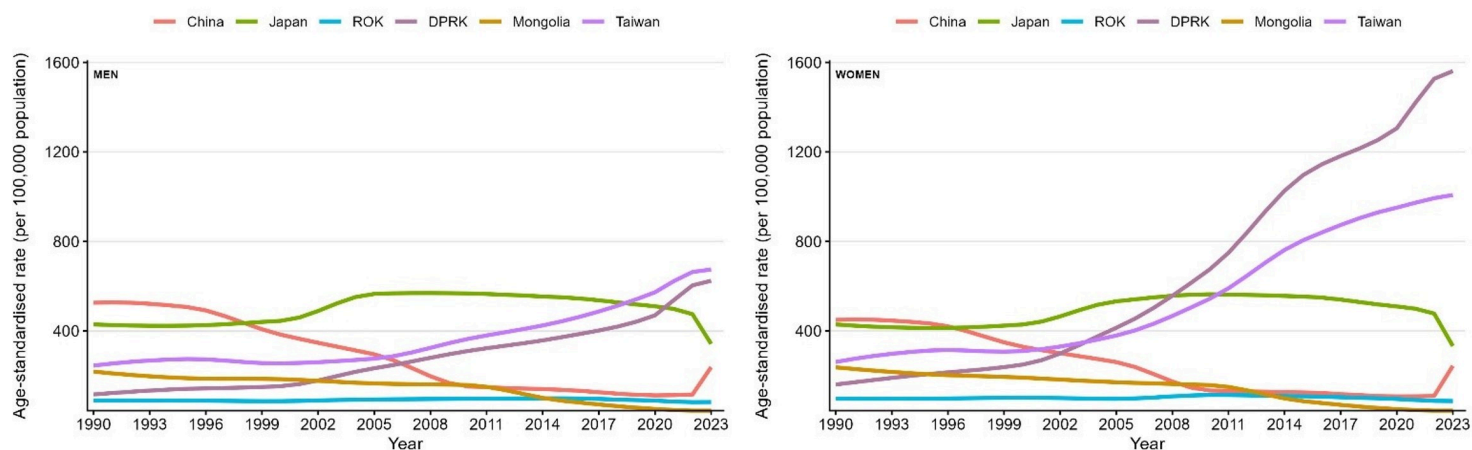
Figure 2

Age-standardised prevalence and DALYs of typhoid and paratyphoid fevers, 1990 and 2023

(A) Prevalence, (B) DALYs. Rates are expressed per 100 000 population. Panel A shows prevalence and panel B shows DALYs; the left panel represents 1990 and the right panel represents 2023.

Abbreviations: ASR, age-standardised rate; DALYs, disability-adjusted life-years.

A



B

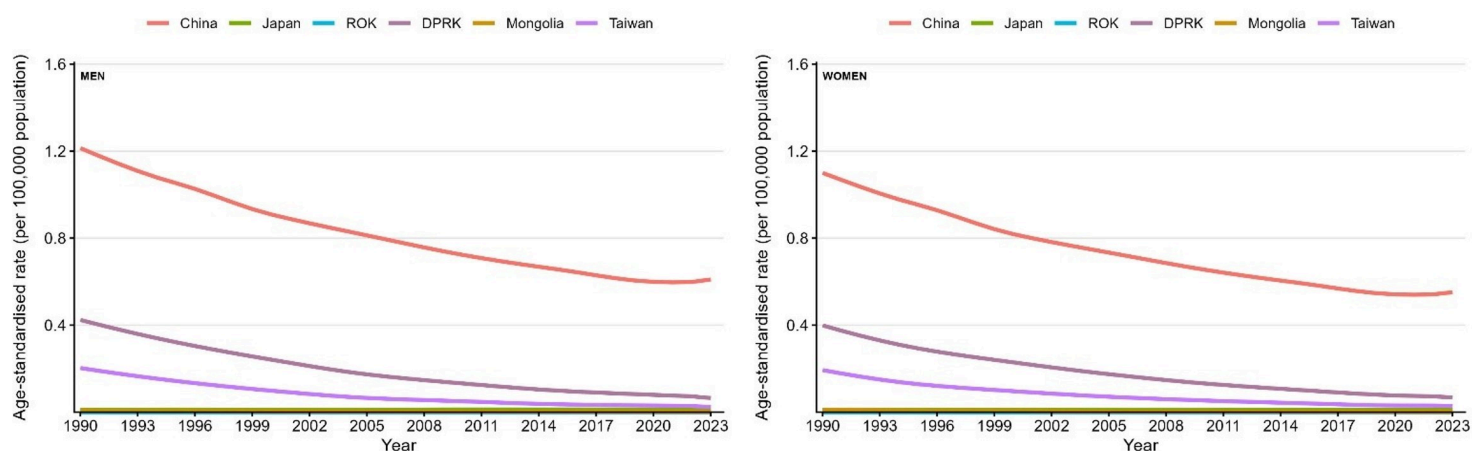


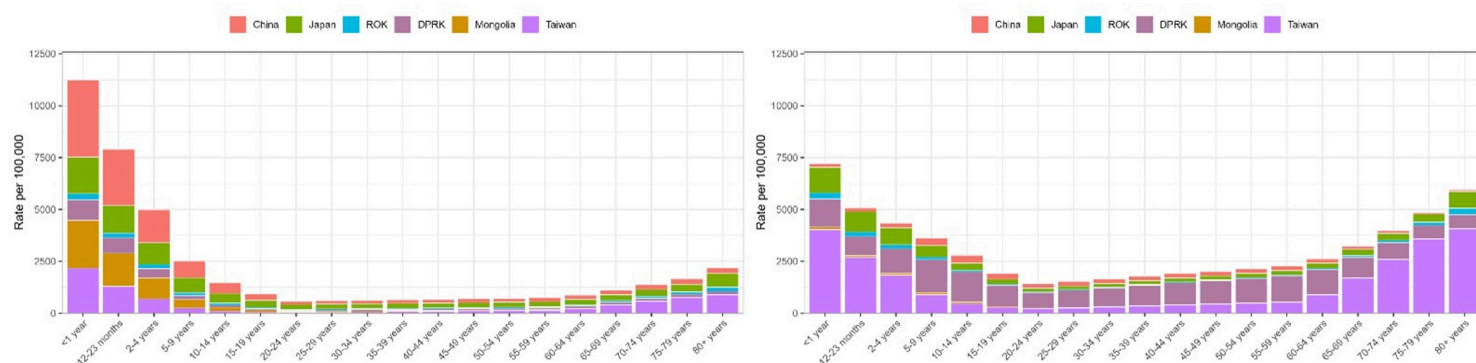
Figure 3

Trends in age-standardised prevalence of diarrhoeal diseases and typhoid and paratyphoid fevers by sex, 1990–2023

(A) Diarrhoeal diseases, (B) Typhoid and Paratyphoid fevers. Rates are expressed per 100 000 population. The change between 2022 and 2023 in China and Japan reflects a discontinuity in the GBD 2023 non-fatal estimates (see Methods, Sensitivity analysis).

Abbreviations: ROK, Republic of Korea; DPRK, Democratic People’s Republic of Korea.

A



B

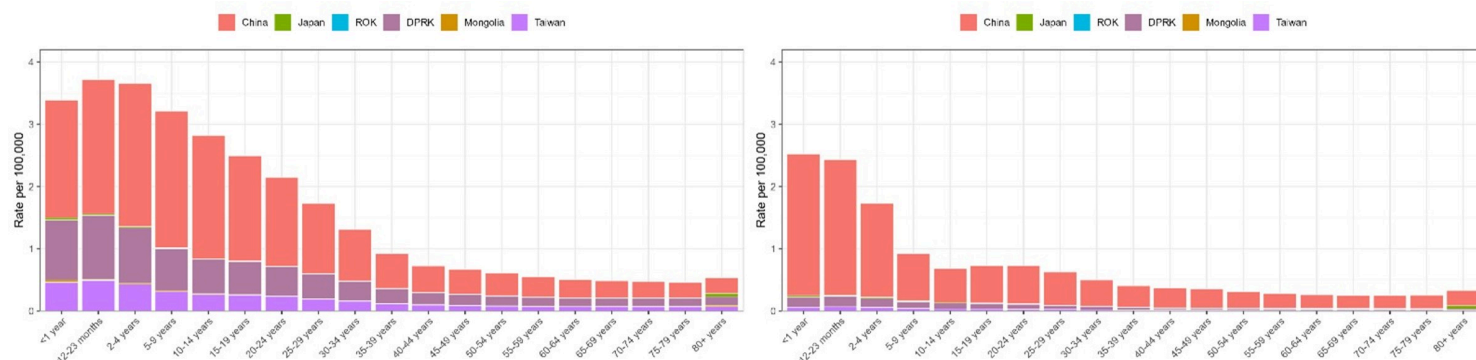


Figure 4

Age-specific prevalence of diarrhoeal diseases and typhoid and paratyphoid fevers in 1990 and 2023

(A) Diarrhoeal diseases, (B) Typhoid and Paratyphoid fevers. Rates are expressed per 100 000 population.

Abbreviations: ROK, Republic of Korea; DPRK, Democratic People's Republic of Korea.

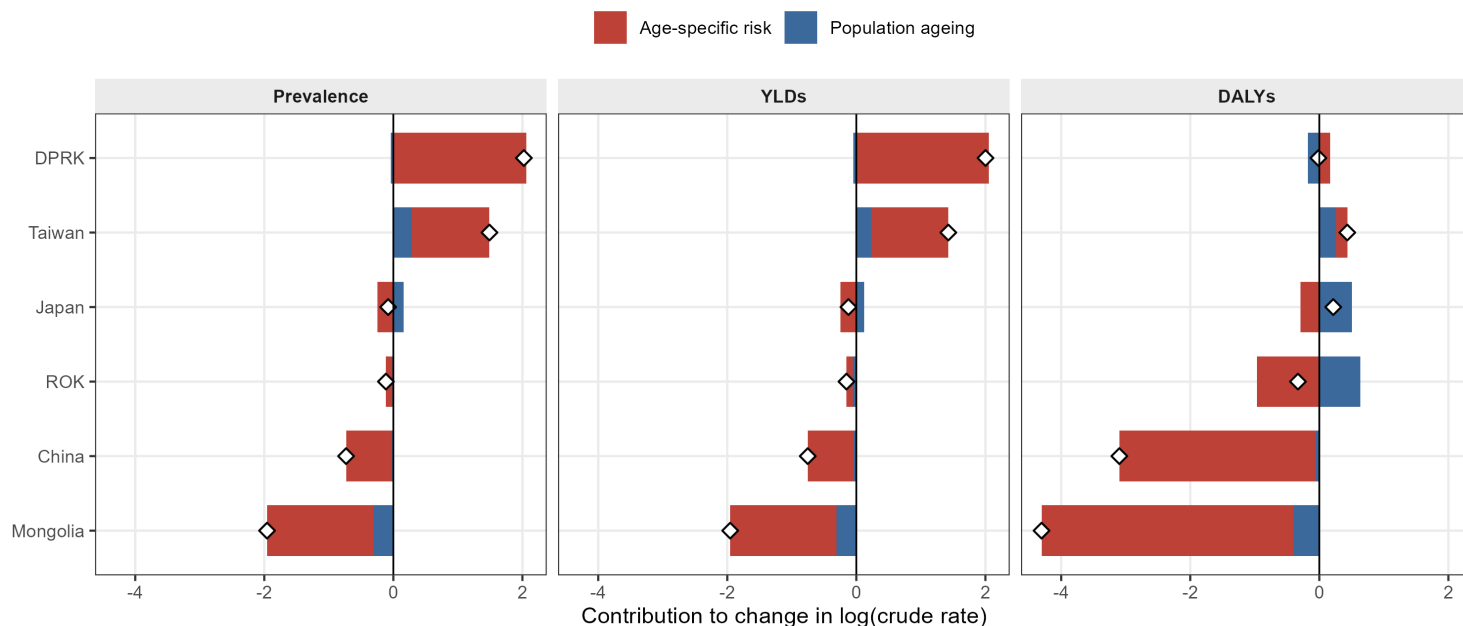


Figure 5

Decomposition of change in crude diarrhoeal disease rates into epidemiological and demographic components, 1990–2023

Bars show the additive contribution of change in age-specific risk (the age-standardised rate) and of population ageing (the age-structure term) to the total change in the crude rate, on the natural log scale. Diamonds indicate the total change. Panels show prevalence, YLDs and DALYs.

Abbreviations: ROK, Republic of Korea; DPRK, Democratic People's Republic of Korea; YLDs, years lived with disability; DALYs, disability-adjusted life-years.

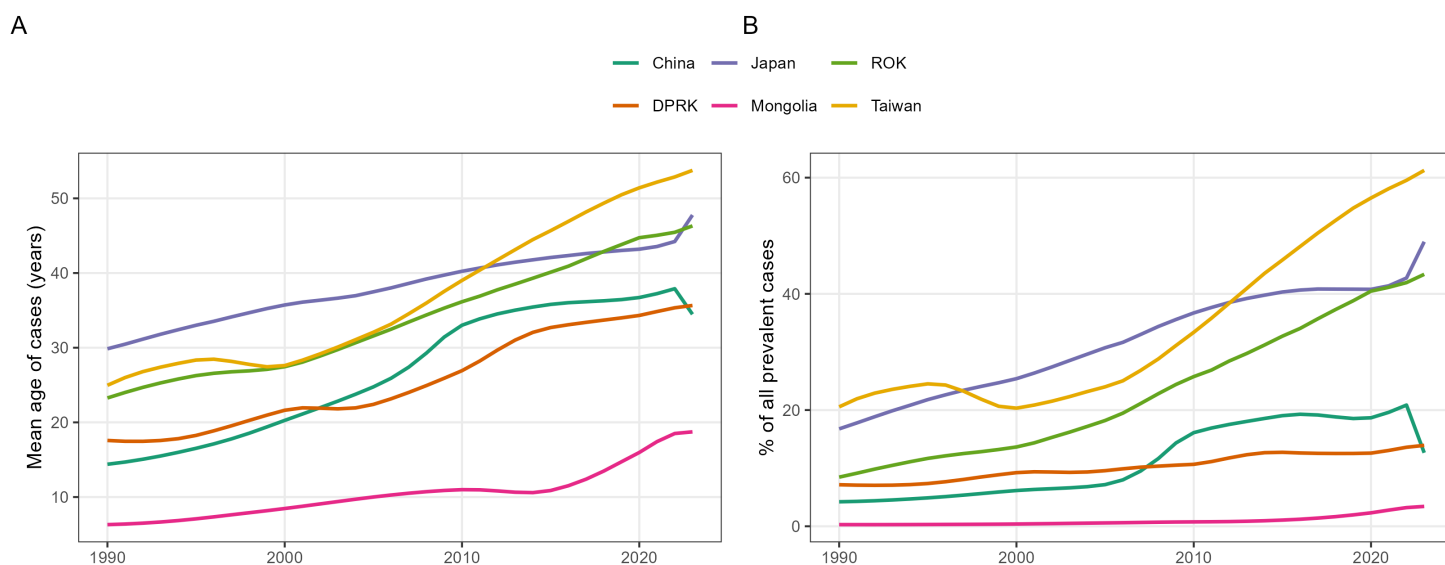


Figure 6

Age distribution of prevalent diarrhoeal disease cases, 1990–2023

(A) Mean age of prevalent cases, computed using age-group midpoints. (B) Proportion of prevalent cases occurring in adults aged 60 years and older. Both quantities are derived from age-specific case counts and are independent of the choice of standard population. The change between 2022 and 2023 in China and Japan reflects a discontinuity in the GBD 2023 non-fatal estimates (see Methods, Sensitivity analysis).

Abbreviations: ROK, Republic of Korea; DPRK, Democratic People's Republic of Korea.

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